**NASA DEVELOP National Program**

**2018 Fall Project Proposal**

**Alabama – Marshall**

**Gulf of Mexico Transportation & Infrastructure**

*Evaluating the Potential of CYGNSS Wind Data to Assess Tropical Storm Impacts on Energy Infrastructure in the Gulf of Mexico*

**Project Overview**

***Project Synopsis*:** This project aims to provide the Bureau of Ocean Energy Management with another tool for promoting safety and protecting the environment in the Gulf of Mexico (GOM). The team will evaluate the potential of the CYGNSS constellation to assess the impacts of tropical storms on energy infrastructure, such as oil rigs, within the Gulf of Mexico. Combined with wave height from Jason-3 and ancillary datasets, the team will create wind and wave intensity maps and a time series analysis of the 2017-2018 tropical storm season. These products will illustrate storm intensity based on wind speeds and wave heights, as well as analyze the potential impact of wind and waves on energy infrastructure. The results will be compared to ASCAT scatterometer and MERRA-2 data to illustrate the benefits and limitations of CYGNSS. Incorporation of this new NASA Earth observation into the partner’s suite of tools will enhance their environmental studies within the Gulf of Mexico and their recommendations regarding the fulfillment of federal environmental policies.

***Community Concern:*** Offshore crude oil production in the Gulf of Mexico accounts for 17% of the total US oil production. Tropical storms and hurricanes regularly impact energy infrastructure negatively in this region, with 2-3 hurricanes or tropical storms reaching the coast each year. When a tropical storm is imminent, oil rigs, transportation pipelines, processing plants, and other energy infrastructure and transportation in the expected path of the storm shut down and crews are evacuated. Damage is assessed after the storm passes, and repairs can delay production from a couple of days to months, creating instability in energy production.

***Source of Project Idea:*** This project idea was formulated by the Alabama – Marshall science advisors and Dr. John Mecikalski, professor and interim chair of the Atmospheric Science Department at the University of Alabama in Huntsville. Dr. Mecikalski suggested the evaluation of CYGNSS as a method for enhancing the assessment of wind impacts on energy infrastructure due to its capacity to capture data through precipitation. The Bureau of Ocean Energy Management (BOEM) confirmed that the end products are applicable to them, and that this project may align with the objectives of an ongoing study BOEM is conducting with The Water Institute of the Gulf.

***National Application Areas Addressed:*** Transportation & Infrastructure, Energy

***Study Location:*** Gulf of Mexico; TX, LA, MS, AL, FL

***Study Period:*** March 2018 – September 2018

***Advisors:*** Dr. Jeffrey Luvall (NASA Marshall Space Flight Center), Dr. Robert Griffin (University of Alabama in Huntsville), Dr. John Mecikalski (University of Alabama in Huntsville), Dr. Xuanli Li (University of Alabama in Huntsville)

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Bureau of Ocean Energy Management, Gulf of Mexico Outer Continental Shelf Region, Office of Environment** | Greg Kozlowski, Deputy Regional Supervisor | End User | No |

***End-User Overview***

***End User’s Current Decision-Making Process:***The Bureau of Ocean Energy Management, Gulf of Mexico Outer Continental Shelf Region, Office of Environment assesses the environmental impact of mineral extraction and conducts studies regarding extraction of oil, gas, salt, sulfur, and more in the Gulf of Mexico. These studies primarily rely on *in situ* observations. The Office of Environment is responsible for the extraction of gravel, sand, and other non-energy minerals and oversees pre-leasing environmental activities. Throughout these activities, the Office of Environment coordinates with other stakeholders, such as state governments, to ensure the federal environmental policies are being met, like the National Environmental Policy Act (NEPA), the Marine Mammal Protection Act, and more. The BOEM Studies Program supports this decision-making process by providing the necessary information to complete the NEPA analysis prior to making a NEPA determination.

***End User’s Capacity to Use NASA Earth Observations:***

*Bureau of Ocean Energy Management, Gulf of Mexico Outer Continental Shelf Region, Office of Environment* – BOEM has used remote sensing data in the past to analyze natural seeps in the Gulf of Mexico. Remote sensing techniques have been considered for use in recent studies to manage emissions inventories for Outer Continental Shelf oil and gas operations. Assessment of mineral extraction environmental impact relies primarily on in-person assessments, although some remote sensing methods are utilized. The Office of Environment does not use NASA Earth observations; therefore, this project will provide them with another tool to investigate how risk to energy infrastructure in the Gulf of Mexico may impact the environment.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The Center Lead will schedule a conference call for the first week of the term for participants and partners introductions and to determine if there are any adjustments that need to be made to the end products. The Project Lead will be the main POC for the partners throughout the term and will update them weekly via email as well as organizing meetings once every one or two weeks.

***Transition Plan*:** At the end of the term, end products and results will be disseminated to the project partner through a web conference. During this meeting, the team will give a presentation of the results and field any questions that the partners may have. This will be followed by a tutorial explaining how to use the end products.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **CYGNSS DDMI** | Wind speed | The wind speed product derived from CYGNSS will be combined with altimetry and ancillary datasets to illustrate risk to energy infrastructure. |
| **Jason-3 Altimeter** | Wave height | The wave height and sea level products from Jason-3 will be combined with CYGNSS wind speed and ancillary datasets to illustrate risk to energy infrastructure. |
| **Metop-A ASCAT** | Wind vector | The wind speed and direction product from ASCAT will be used to compare with wind speed data retrieved from CYGNSS. |

***Ancillary Datasets:***

US Energy Information Administration Energy Infrastructure Real-time Storm Information for the Gulf of Mexico – use to evaluate potential impact on infrastructure as assessed by the team

Homeland Infrastructure Foundation-Level Data (HIFLD) Offshore Oil and Gas Platforms in the Gulf of Mexico – locations of energy infrastructure to evaluate potential impact of tropical storms

NOAA Oil Rig Weather Observations – compare to CYGNSS wind speed

NOAA National Data Buoy Center Gulf of Mexico Buoy Weather Data – compare to CYGNSS wind speed

NASA Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2) Atmospheric Reanalysis 2 – compare to wind speed from CYGNSS

***Modeling:***

Fuzzy Logic Modeling (POC: Helen Baldwin, DEVELOP)

***Software & Scripting:***

R – statistical analysis

Esri ArcGIS – Raster manipulation and analysis, imagery processing, and map production

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Potential Storm Intensity Analysis** | The potential storm analysis will assess wave heights and wind speeds during severe weather events and non-events. This will provide further insight regarding severe weather trends in the GOM. | CYGNSS wind speed data will be processed using ArcGIS to produce averaged, interpolated wind maps for the study period. Jason-3 wave height data will be process and using ArcGIS, and combined with wind speed data using Fuzzy Logic. Additionally, basic statistics for wind speed calculated for severe weather events within the study period. | N/A |
| **CYGNSS, ASCAT, and MERRA-2 Wind Speed Comparison** | This comparison product will illustrate the limitations of the end products produced by this project utilizing CYGNSS as opposed to the ASCAT scatterometers and MERRA-2, and validated with *in situ* wind speed measurements from the NOAA National Data Buoy Center. | Wind speed data from CYGNSS, ASCAT and MERRA-2 will be compared to assess the benefits of utilizing the CYGNSS satellite constellation versus other sensors, and validated with *in situ* measurements from the NOAA National Data Buoy Center. | N/A |
| **Energy Infrastructure Risk Map** | This product will provide BOEM with another tool for assessing the risk to energy infrastructure within the Gulf of Mexico due to severe weather and subsequently how infrastructure damage may impact the environment. Risk to mineral extraction infrastructure due to waves can be utilized in BOEM conducted studies pertaining to mineral extraction. | The storm intensity from CYGNSS will be overlaid in ArcGIS using Fuzzy Logic modeling along with energy infrastructure locations in order to illustrate risk to energy infrastructure for summer 2018. | N/A |

***End-User Benefit*:** This project has the potential to support the NEPA analysis BOEM conducts for offshore energy production in the Outer Continental Shelf and supporting coastal infrastructure. Knowing the wind speed and wave height of storms in the GOM and how they impact energy infrastructure will assist BOEM in developing future models to consider storm impacts. An alternative way of calibrating storm surges would be particularly useful for the BOEM supported study, *Assessing Temporal and Spatial Variability in Community and Parish Level Responses to Oil Spills and Other Events in Coastal Louisiana* conducted by The Water Institute of the Gulf.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2018 Fall

***Related DEVELOP Work:***

2013 Spring (SLU) – Midwest Weather: Improved Small-Scale Wind Forecasting Capability

2017 Summer (NCEI) – Philippines Disasters: Utilizing NASA and NOAA Earth Observations to Enhance Cyclone Movement and Intensity Measurements to Improve Disaster Relief Planning in the Philippines

2016 Summer (NCEI) – Pacific Water: Enhancing Decision Making to Help Manage Freshwater Resources: Using NASA Observations and NOAA CDR’s to Provide Near Real-Time Precipitation Estimates for Forecasting in the U.S. Affiliated Pacific Islands

**Notes & References:**

***Notes*:** Damage data from summer 2018 would improve the Energy Infrastructure Risk Map by allowing the team to make specific relationships between the wind speeds, wave heights, and actual damages caused.

***References:***

Murray, J. J., Ruf, C., Baker, N., Lang, T., Uhlhorn, E., Masters, D., …, Molthan, A. (2015). Report on the NASA CYGNSS mission applications workshop. Retrieved from: http://clasp-research.engin.umich.edu/missions/cygnss/reference/cygnss-mission/CYGNSS\_Applications\_Workshop\_May2015.pdf

Ruf, C., Chang, P.S., Clarizia, M.P., Gleason, S., Jelenak, Z. Murray, J., …, Zavorotny, V. (2016). CYGNSS handbook. Ann Arbor, MI: Michigan Publishing.

Ruf, C., Atlas, R., Chang, P. S., Clarizia, M. P., Garrison, J. L., Gleason, S., …, Zavorotny, V. U. (2016). New ocean winds satellite mission to probe hurricanes and tropical convection. *Bulletin of the American Meteorological Society*, 385-395. doi:10.1175/BAMS-D-14-00218.1